Title of the Invention:

FUEL INJECTOR AND ITS CONTROL METHOD

Background of the Invention:

<Field of the Invention>

The present invention relates to a fuel injector having a fuel injection valve, which is mounted in an internal -combustion engine to control the amount of fuel supplied, and to a method of controlling the fuel injector.

In general, a fuel injection valve comprises a fuel injection orifice, a valve seat disposed in its vicinity, a valve body slidably supported in an axial direction at the posi tion facing the valve seat, and a spring. The spring generates the force that presses the valve body in the direction of the valve seat.

While the valve seat and the valve body are being kept in a contact status by the spring force, that is to say, under the closed status of the valve, since the fuel passageway is closed, fuel is not injected from the fuel injection orifice.

The fuel injection valve also has a magnetic circuit and coil assembly for driving the valve body. The application of a current to t he coil assembly exerts magnetic attraction force on the valve body, hereby sliding the valve body in an axial direction, and moving the valve body away from the valve seat to open the valve.

At this time, since the fuel passageway is opened, fuel is injec ted from the fuel injection orifice. In the fuel injection valve, the amount of

fuel supplied can be controlled by adjusting the time for which the open status of the valve is maintained.

To precisely control the amount of fuel supplied to the internal-combustion engine, it is necessary to reduce the minimum amount of injection that is the minimal value of the controllable amounts of fuel supplied. To achieve the reduction, the valve body needs to be opened at high speed, and hereby, supply of a current to the coil assembly needs to be rapidly started.

<Prior Arts>

A patent document 1 (Japanese Application Patent Laid-Open Publication No. Hei 08-45735) exemplifies the conventional technology related to the above.

According to the patent document 1, in an electromagnetic load-driving method that uses at least one series circuit which includes a load and a changeover means, changeover control is provided so that supply of a current to the coil assembly can be rapidly started by setting small resultant inductance for a first time interval, in other words, for valve opening, and so that large resultant inductance can be set for a second time interval, the valve-opening retention duration following the above-mentioned first time interval.

Summary of the Invention:

Under the conventional technology described above, however, resultant inductance is changed between the first time interval and second time interval mentioned above, and more specifically, resultant

inductance is changed from a low value to a high value , between the first time interval for which the starting time of supply of the current is to be minimized, and the second time interval for which, although a hold current is required, too fast responsiveness is not required. No problems would occur in the case that the power voltage does not change.

However, in particular, when the power supply actually used is a battery, its voltage changes cannot be avoided. A fuel injector needs to operate its valve body at high speed and stably, even when power voltage changes occur. For this reason, greater magnetomotive force, in other words, larger integer value of the ampere -turns within the required time, is preferable.

However, in the case of the patent document 1 mentioned above, no consideration is given to ch anges in magnetomotive force due to changes in power voltage.

An object of the present invention is to provide: a fuel injector that can suppress changes in the amount of injection from its fuel injection valve by solving the above-described problems and operating the valve body at high speed and stably, even when power voltage changes occur, and thereby obtain stable fuel injection characteristics; and a method of controlling the fuel injector.

In the present invention, which is intended to achieve high -speed and stable operation of the valve body by providing connection changeover control of coils when power voltage changes occur in the coil-equipped fuel injection valve, the problems described above can be solved by using the following means:

In the fuel injector that comprises a direct-current power supply, a power voltage detection means, a coil-equipped fuel injection valve, and a control unit for controlling said fuel injection valve, the control unit outputs a changeover signal for changing the magnit ude of resultant inductance of the coil in accordance with a power voltage detection value sent from the power voltage detection means.

Also, in the present invention, a reference value of the power voltage is set beforehand and the control unit outputs a control signal so that when a detected power voltage value is less than the foregoing reference value, the resultant inductance of the coil is reduced, and when the detected power voltage value is greater than the foregoing reference value, the resultant inductance of the coil is increased.

In addition, in the present invention, the fuel injection valve has a plurality of coils and when resultant inductance is to be set to a large value, the above-mentioned plurality of coils are connected in series, and when resultant inductance is to be set to a small value, the above-mentioned plurality of coils are connected in parallel.

According to the present invention, even when power voltage changes occur, it is possible to operate the valve body at high speed and stably and stabilize the amount of fuel injection with respect to the same injection command pulse width. Accordingly, it is possible to provide a fuel injector that can stabilize the operational status of an internal-combustion engine.

Brief Description of Drawings:

Fig. 1 is a block diagram representing an embodiment of the fuel injector pertaining to the present invention;

Fig. 2 is a cross-sectional view representing an embodiment of the fuel injection valve constituting the fuel injector of the presen t invention;

Fig. 3 is a timing chart explaining the operation of the fuel injector pertaining to the present invention;

Fig. 4 is a diagram showing the relationship between the fuel injection pulse and the amount of fuel injection;

Fig. 5 is another timin g chart explaining the operation of the fuel injector pertaining to the present invention;

Fig. 6 is a diagram showing the operation of the changeover switches of the fuel injector pertaining to the present invention, and the connection relationship betwee n coils;

Fig. 7 is a flowchart explaining the fuel injector of the present invention;

Fig. 8 is a diagram explaining the relationship between changes in power voltage and changes in the amount of fuel injection;

Fig. 9 is a view showing another embodiment of the present invention;

Fig. 10 is a view showing yet another embodiment of the present invention; and

Fig. 11 is a diagram that shows examples in which V_{th} is varied according to a particular fuel pressure or the particular resistance value of harness.

Description of the Invention:

In the fuel injector that comprises a direct-current power supply, a power voltage detection means, a coil-equipped fuel injection valve, and a control unit for controlling the fuel injection valve, the fuel injection valve has a plurality of coils and the control unit outputs a changeover signal for changing the magnitude-of-resultant inductance of the plurality of coils of the fuel injection valve in accordance with a power voltage detection value sent from the power voltage detection means.

The control unit is also adapted to set a reference value of a power voltage beforehand and output a changeover signal by which, when a value that has been detected by the power voltage detection means is less than the reference value that has been set beforehand, the resultant inductance of the coils is reduced, and when the power voltage detection value is greater than the reference value, the resultant inductances of the coils is increased.

Fig. 1 is a block diagram representing an embodiment of the fuel injector according to the present invention. Fig. 2 shows the composition of the fuel injection valve constituting the fuel injector to which the present invention applies.

First, the basic operation of the fuel injection valve is described below using Fig. 2. Fig. 2 is a cross-sectional view showing an embodiment of the fuel injection valve constituting the fuel injector of the present invention. An orifice plate 1 is provided with a fuel injection orifice 2 and a valve seat 3. The orifice plate 1 is fixed to an end portion of a nozzle holder 11 by using a method such as welding. A swirler 12

for swirling fuel is provided between the orifice plate 1 and the nozzle holder 11.

Also, a guide plate 13 is fixed inside the nozzle holder 1 1. A valve body 4 is guided in a sliding condition by a hole provided in the center of the guide plate 13, and an inside-diameter section of the swirler 12.

The valve body 4 comprises a movable iron core 5, a tubular member 6, and a rod 7, all of which ar e connected by using a method such as welding. A damper plate 8 provided inside the movable iron core 5 has an outer-surface section supported vertically by an upper edge of the tubular member 6.

An interlocking member 10 is slidably supported in an axial direction inside an inner fixed iron core 9. The interlocking member 10 has a front end brought into contact with an inner-surface section of the damper plate 8. The damper plate 8 has its outer-surface section supported, and its inner-surface section axially warped, hereby functioning as a plate spring.

The nozzle holder 11 is fixed to the inside of a nozzle housing 14. A ring 15 for adjusting a stroke of the valve body 4 is provided at an upper end of the nozzle holder 11. A spring pin 19 is fixed in side the inner fixed iron core 9. With a lower end of the spring pin 19 as its fixed end, a spring 20 is provided in a compressed condition.

Numeral 21 denotes a fuel supply port. Spring force is transmitted to the valve body 4 via the interlocking membe r 10 and the damper plate 8, and the valve body 4 is pressed against the valve seat 3. Under this closed status of the valve, since the fuel passageway is closed, fuel that has been supplied from the fuel supply port 21 stays inside the fuel

injection valve and hereby, fuel is not injected from the fuel injection orifice 2.

A magnetic circuit routed around a first coil 100 and a second coil 101 is constituted by the nozzle housing 14, the movable iron core 5, the inner fixed iron core 9, a plate housing 16 , and an outer fixed iron core 17.

When an injection command pulse turns on, a current flows into a series circuit formed by the first coil 100 and the second coil 101, then the movable iron core 5 is attracted to the inner fixed iron core 9 by electromagnetic force, and the valve body 4 moves to a position at which its upper edge comes into contact with the lower edge of the inner fixed iron core 9.

Under this open status of the valve, since a clearance is created between the valve body 4 and the valve seat 3, the fuel passageway is opened and fuel that has been supplied from the fuel supply port 21 is swirled by the swirler 12 and injected from the fuel injection orifice 2.

When the injection command pulse turns off, the flow of the current into the first coil 100 and the second coil 101 is stopped and since the electromagnetic force disappears, the valve body 4 returns to a closed status by spring force to terminate the injection of the fuel.

The function of the fuel injection valve is to control the amount of fuel supplied, by changing the valve body 4 to an open status or a closed status, depending on the injection command pulse status, and then adjusting the retention time of the open valve status.

To precisely control the amount of fuel supplied to an internal-combustion engine, it is important that the amount of fuel injection with

respect to the same injection command pulse width should always be stable.

An embodiment of the fuel injector according to the present invention is described below using Fig. 1.

In Fig. 1, a power supply 103 and a current detector 104, together with a first switch 105, a second switch 106, and a third switch 107, are connected to a first coil 100 of a fuel injection valve and to a second coil 101 thereof.

The power supply 103 here can be either a battery mounted in a vehicle or a high-voltage generator consisting of a combination of a battery and a booster circuit which includes, for example, a DC/DC converter. The power supply can be any device, provided that it can supply electric power to the fuel injection valve. To make the fuel injection system less expensive, however, it is preferable that the power supply be a battery for a vehicle.

Although it is preferable that the current detector 104 be able to use a current detection resistor, the type of current detector 104 is not limited by this statement and other means can be used alternatively, provided that it can detect current values. A voltage of the power supply 103 is measured by a voltage detection means 108, and its detected voltage V_{103} is sent to a control unit 102.

The currents flowing into the first coil 100 and the second coil 101 or the sum of the currents flowing into both coils is measured by the current detector 104, and the results are sent to the control un it 102. Although not shown in the figure, operational status information, such as

an internal-combustion engine speed, is also input to the control unit 102.

Inside the control unit 102, the injection command pulse corresponding to the amount of fuel injection required according to a particular operational status of the internal-combustion engine is created and a signal for controlling the changeover between the first switch 105, the second switch 106, and the third switch 107, is output, based on that injection command pulse.

A certain voltage judgment reference value (V_{th}) is provided for the voltage detection value that has been measured by the voltage detection means 108 of the power supply 103. The fuel injector operation or switch opening/closing under the status that the voltage detection value is greater than the voltage judgment reference value is described below using Fig. 3.

When, as shown in Fig. 3 (A), an injection command pulse signal 110 turns on at "t_0", the control unit 102 outputs a control signal for, as shown in Fig. 3 (C), connecting the first switch 105, the status of which is represented as numeral 117, and as shown in Fig. 3 (D) and (E), disconnecting the second switch 106 and the third switch 107, the status of which is represented as numerals 118 and 119.

Thereby, the first coil 100 and the second coil 101 are connected in series with respect to the power supply 103. The resultant inductance of the first coil 100 and the second coil 101, when viewed from the power supply 103, increases.

The voltage at both ends of the series-connected first coil 100 and second coil 101, namely, the voltage between points A and D, takes the

waveform shown as numeral 111 in Fig. 3 (B). Here, the current flowing through the series-connected first coil 100 and second coil 101, namely, the current I flowing between points A and D, can be rapidly increased by appropriately setting the relationship between the voltage and the resultant inductance and resistance value of the coils.

Accordingly, magnetomotive force (ampere-turns) that is the product of this current value and the total number of turns of the first coil 100 and second coil 101 also rapidly increases. This state is shown as numeral 112 in Fig. 3 (F).

Since the magnetic attraction force exerted on the valve body 4 also increases rapidly, the displacement thereof takes the form shown as numeral 113 in Fig. 3 (G), thus opening the valve at high speed. After a fixed time, that is to say, after the elapse of time T as shown in Fig. 3 (F), the control unit 102 generates a control signal for repeating the disconnection and connection of the first switch 105 so that magnetomotive force becomes relatively low retention magnetomotive force (fh).

After that, when the fuel injection command pulse turns off at "te", the control unit 102 generates a control signal for disconnecting the first switch 105. Hereby, since the coil current disappears, the valve body returns to a valve-closing position. Under this operation sequence, the amount-of-injection characteristics represented with the fuel injection command pulse width taken on the abscissa, and the amount of fuel injection, on the ordinate, appear as a fuel injection characteristics curve 120 shown in Fig. 4.

However, the voltage of the power supply 103 frequently changes. In particular, when a battery for an automobile is employed as the power supply 103, the voltage could decrease to about 6 V, as represented by numeral 114 in Fig. 3 (B). In other words, the voltage may change to a value smaller than the voltage judgment reference value V_{th}.

At this time, supposing that the resultant inductance of the coils is great as described above, since the current flowing through the coils would also decrease, the response characteristics of magnetomotive force would decrease, hereby taking such a form as denoted by numeral 115 in Fig. 3 (F). Because of the magnetomotive force (ampere -turns) lacking, the displacement of the valve would take such a form as denoted by numeral 116 in Fig. 3 (G), thus making valve op ening incomplete. In extreme cases, the fuel injection valve might not open.

More specifically, the amount-of-injection characteristics of the fuel injection valve might appear as a characteristics curve 121 or 122 shown in Fig. 4. In other words, even if the same injection command pulse width is assigned, the amount of fuel injection would decrease. If this is the case, since the amount of fuel injection according to the particular operational status of the internal-combustion engine cannot be supplied, trouble will be caused to the operation of the internal -combustion engine.

Under this operation sequence, the amount-of-injection characteristics represented with the fuel injection command pulse width taken on the abscissa, and the amount of fuel injecti on, on the ordinate, would change from the characteristics shown as 120 in Fig. 4, to the characteristics shown as 121 or 122.

In order to solve this problem, the considerations described below are incorporated into the present embodiment. The operation o f the fuel injector existing when the voltage value of the power supply 103 is smaller than the above-mentioned voltage judgment reference value V_{th}, is described below using Fig. 5.

Under the status of $V_{103} \leq V_{th}$, when the injection command pulse turns on at "t_0" as represented by numeral 110 in Fig. 5 (A), the control unit 102 outputs a control signal for disconnecting the first switch 105 as represented by numeral 117 in Fig. 5 (C), and connecting the second switch 106 and the third switch 107 as represented by numerals 118 and 119 in Fig. 5 (D) and (E). Hereby, the first coil 100 (N1) and second coil 101 (N2) shown in Fig. 1 are connected in parallel with respect to the power supply 103.

Accordingly, the resultant inductance of the first coil 100 and t he second coil 101, when viewed from the power supply 103, can be reduced. Hereby, since high-speed response of the magnetomotive force can be obtained, it becomes possible to obtain such a magnetomotive force waveform as represented by numeral 112 in Fig . 5 (F). Consequently, as represented by numeral 113 in Fig. 5 (G), the displacement of the valve body can be made fast and stable.

After a fixed time, that is to say, after the elapse of time T as shown in Fig. 5 (F), the control unit 102 generates a con trol signal for repeating the disconnection and connection of the second switch 106 and third switch 107 so that the total magnetomotive force becomes relatively low retention magnetomotive force (fh).

To control retention magnetomotive force "fh" by connecting the two coils in parallel, it is preferable that the current value of the current detector 104 should be controlled so as to be about twice the current value thereof obtained in the case of series connection.

When the fuel injection command pulse tu rns off, the control unit 102 generates a control signal for disconnecting the second switch 106 and the third switch 107, hereby making the coil current disappear and returning the valve body to a valve-closing position.

Here, the series/parallel connection relationship between the first switch 105, the second switch 106, the third switch 107, the first coil 100, and the second coil 101, is arranged in order. This arranged state of the relationship is shown in Fig. 6. When $V_{103} > V_{th}$, this denotes a normal status. Conversely, when $V_{103} \leq V_{th}$, changeover control is conducted for the switches since the power voltage is judged to be too low.

In this way, providing the judgment reference value V_{th} for the changeover of the switch connection form makes it po ssible to switch the series/parallel connection of the first coil and the second coil when the power voltage becomes equal to, or less than, the above reference value. It becomes possible, by doing so, to obtain the same valve-opening characteristics as those obtained in the case of series connection.

This status is shown as solid lines in Fig. 3 (F) and (G) and Fig. 5 (F) and (G). Therefore, stable injection characteristics can be obtained without changes in the fuel injection characteristics 120 of Fig . 4.

The processing flow in the control unit 102 is shown in Fig. 7. In step 7a, it is judged whether the power voltage V_{103} or the voltage

judgment reference value V_{th} is greater. If the relationship of $V_{103} \leq V_{th}$ holds, series/parallel connection between the first coil 100 and the second coil 101 is changed in step 7c.

That is to say, the connection is changed by turning off the first switch 105 and turning on the second switch 106 and the third switch 107. See Fig. 6. Conversely, when $V_{103} > V_{th}$, this status is judged to be normal and the coils remain connected in series as shown in step 7b. Also, see Fig. 6.

Under this operation sequence, the amount-of-injection characteristics represented with the fuel injection command pulse width taken on the abscissa, and the amount of fuel injection, on the ordinate, take the form shown as 120 in Fig. 4, and regardless of a low-voltage status, it becomes possible to maintain a status as stable as the fuel injection characteristics obtained when the voltage is high.

More specifically, even when the power voltage changes, it becomes possible to suppress changes in the amount of fuel injection with respect to the same injection command pulse width, and thus to always stabilize the amount of injection. Hereby, the amount of fuel injection according to the particular operational status of the internal-combustion engine can be supplied and this, in turn, enables stabilized operation of the internal-combustion engine.

Next, the relationship between power voltage changes and fuel injection characteristics is described below using Fig. 8. Suppose that normal power voltage V_{103} is 14 v. The amount of fuel injection at this time is expressed as Fn. The case that this power voltage V_{103}

decreases to 7.0 (v) is described here. In this case, when V_{th} is set to 7.0 (v), the connection between the first coil 100 and the second coil 101 is changed at this time.

More specifically, a coil changeover signal is output from the control unit 102 and the connection between the first coil 100 and the second coil 101 is changed from series connection to parallel connection. If both coils remain connected in series at V_{103} = 7.0 (v), the amount of fuel injection decreases to F1 (<Fn). The amount of injection, however, can be recovered to the vicinity of Fn by changing the connection of the coils.

Fig. 8 shows an example in which the connection between both coils is changed when V_{103} = 7.0 (v). However, the optimum value needs to be set since the characteristics in Fig. 8 change according to the fuel injection characteristics against the power voltage, more particularly, according to the characteristics of the fuel injection valve.

In general, it is desirable that when voltage V_{103} decreases to a range from about 7.0 to 9.0 (v), the connection between the coils should be changed. Or conversely, after the tolerance of changes in the amount of fuel injection has been determined, above-described changeover control can be conducted when the tolerance is reached.

For example, since characteristics "Fc" exhibit nonlinearity with respect to power voltage changes, when the power voltage decreases to half its original value, "F1 = (1/2) Fn" does not always hold. Therefore, the connection between the coils 100 and 101 can also be changed when the condition of "(Fn - Fc) > Fg (required value)" is established.

In general, changes in the voltage of the power supply 103 cannot

be avoided. In particular, when an automotive battery is employed as the power supply 103, the voltage could decrease to about 6 V, as represented by numeral 114 in Fig. 3 (B).

At this time, if the resultant inductance of the coils is great as described above, the response characteristics of the magnetomotive force are apparently tantamount to having decreased and the magnetomotive force takes such a form as denoted by numeral 115 in Fig. 3 (F). Because of the magnetomotive force lacking, the displacement of the valve takes such a form as denoted by numeral 116 in Fig. 3 (G), thus making valve opening incomplete.

The amount-of-injection characteristics appear as a characteristics curve 121 or 122 shown in Fig. 6, and thereby, there occur changes in the amount of fuel injection with respect to the same injection command pulse width. Hereby, since the amount of fuel injection acco rding to the particular operational status of the internal -combustion engine cannot be supplied, trouble will be caused to the operation of the internal -combustion engine.

Also, it would be possible to use the following methods to judge whether the power voltage V_{103} or the voltage judgment reference value V_{th} is greater.

The methods that can be actually used, however, are not limited to these methods: for example, the relationship in magnitude between the power voltage value and the voltage judgment refere nce value can be judged by converting a detected voltage value into digital signal form by means of an A/D converter provided in either the voltage detection means

108 or the control unit 102, and then using a microcomputer provided in the control unit 102. Or the relationship in magnitude can be judged by entering the power voltage value and the voltage judgment reference value into a comparator.

In addition, there is another method of ensuring the opening operation of the valve when the power voltage decreases. As described above, when the power voltage decreases, the start of augmentation of the magnetomotive force apparently delays as shown in 115 of Fig. 3 (F), and therefore, the magnetomotive force actually required cannot be obtained.

At this time, by increasing the value of T which is the time for changing the magnetomotive force to retention magnetomotive force, the changeover time can likewise be adjusted so that the magnetomotive force becomes great enough to open the valve. This method is also valid for ensuring valve opening.

However, since this method extends the time required for the magnetomotive force to become great enough, the amount -of-injection characteristics are likely to take the form represented as 121 in Fig. 4. For this reason, there occurs a change in the amount of fuel injection corresponding to the same injection command pulse width. Of course, it is also possible, after estimating this spread of change, to provide control so that the injection command pulse width is adjusted.

To simplify engine control, however, it is desirable that the amount of fuel injection corresponding to the same injection command pulse width should always be constant. The present embodiment is advantageous

in that the amount of fuel injection correspo nding to the same injection command pulse width is always constant.

Furthermore, there is yet another method of ensuring the opening operation of the valve when the power voltage decreases. That is to say, valve opening can be achieved by applying voltage only to either the first coil 100 or the second coil 101 when the power voltage decreases. This method can also be such that voltage is applied only to a portion of the coil-wound section of the fuel injection valve.

The use of this method also makes it possible to reduce the resultant inductance of the coils when viewed from the power supply 103, and hereby to augment the magnetomotive force abruptly. However, since the magnetomotive force is consequently applied to a portion of the coil space of the fu el injection valve, current density increases and this poses the problem that the coil temperature increases very significantly.

In the present embodiment, however, since magnetomotive force is applied to the entire coil space of the fuel injection valve a nd thus since current density is controlled to a relatively small value, there is the advantage that increases in the coil temperature can be minimized.

Next, the strand diameters and number-of-turns of the first coil 100 and second coil 101 in the present embodiment are described below. It is desirable that the first coil 100 and the second coil 101 should be the same in strand diameter and in the number of turns. In this case, the responsiveness of the magnetomotive force can be controlled to the same level between both coils, even if the power voltage decreases to about half its original value.

However, even if the strand diameters and number-of-turns of the first coil 100 and second coil 101 are set to different values, there is not a change in that the resultant inductance of the two coils can be reduced by connecting both coils in parallel, and the effects of the present invention are not degraded.

For the present embodiment, as shown in Fig. 3, the scheme in which magnetomotive force is changed to retention magnetomotive force has been described. The effects of the present invention can likewise be obtained by adopting a scheme in which, after a reference value has been provided for the maximum magnetomotive force beforehand, magnetomotive force is changed to retention magnetomotive force at the time of detection of the fact that this reference value has been reached.

In the present embodiment, as shown in Fig. 2, the first coil 100 and the second coil 101 are arranged in the axial direction of the fuel injection valve. Or it is also possible to adopt coil arrangement in which the first coil 100 at the inside-diameter side of the fuel injection valve and the second coil 101 at the outside-diameter side.

This is a method of arranging the coils at right angles, not axially, with respect to the fuel injection valve. It is advantageous to adopt this method in the case that, for example, there are spatial margins in the radial direction of the fuel injection valve, rather than in the axial direction thereof. A schematic view of such arrangement is shown in Fig. 9 (A).

Furthermore, although, in Fig. 1, a method of electrical connection between the first coil 100, the second coil 101, and the power supply 103, has been shown, the electrical connection method, the number of

switches, the number of coils, and other factors are not limited by Fig. 1.

When three or more coils are provided, provided that the connection status of these coils when viewed from the power supply can be changed from series connection to parallel connection, or vice versa, the present invention can also be applied in that case. An example of application in such a case is shown in Fig. 10. In this example, N1 and N2 are the same as in Fig. 1. Two coils are connected in series to a switch 105. Parallel connection is omitted.

Also, in the above embodiment, although a method of changing resultant inductance has been described showing an example in which the power voltage changes, the response of the current may also deteriorate if changes in resistance occur in the coils or in the electrical wiring (namely, harness) for supplying the current to the coils.

If that is the case, the amount-of-injection characteristics can be stabilized by, for example, detecting resistance values directly or indirectly and then increasing or reducing resultant inductance, depending on the resistance values, by use of the method described above.

Referring to the example of Fig. 1, it has been earlier described that when a battery supplying a power voltage of 14 (V) is used, the appropriate voltage judgment reference value V_{th} for series/parallel connection changeover of the coils is from 7 to 9 (V). The voltage judgment reference value V_{th}, however, can be varied according to other conditions.

For example, V_{th} can be varied according to a particular fuel

pressure or the particular resistance value of the harness. Examples are shown in Fig. 11. Fig. 11 (A) shows an example in which the voltage judgment reference value V_{th} is varied according to a fuel pressure. Fig. 11 (B) shows an example in which the voltage judgment reference value V_{th} is varied according to particular changes in the resistance value of the harness.

Furthermore, it may be advisable to vary the responsiveness of magnetomotive force according to a particular fuel pressure level. For example, when the fuel pressure is high, it may be possible for the opening of the valve to be stabilized by reducing the responsiveness of the magnetomotive force.

In this case, the amount-of-injection characteristics can be stabilized by detecting the fuel pressure directly or indirectly and then increasing or reducing resultant inductance, depending on that pressure value, by use of the method described above.

In addition, the effects of the present invention ar e not limited to the case of using the fuel injection valve having such composition as shown in Fig. 2. The effects of the present invention can be obtained for any type of fuel injector, provided that a fuel injection valve which has coils and a magnetic circuit is included in the fuel injector.

According to the present invention, even in case of power voltage changes or the like, it is possible to operate the valve body at high speed and stably, hereby to stably maintain the amount of fuel injection with respect to the same injection command pulse width, and consequently to obtain a fuel injector that can stabilize the operational status of an

internal-combustion engine. According to the present invention, the amount of injection is stably maintained, even when power voltage changes occur.

The present invention can be used for such an electromagnetic valve that uses electromagnetic force to provide fuel supply control, as well as for an automotive fuel injection valve.